THE ASSESSMENT OF SELECTED DECISION TOOLS FOR EVALUATION OF STRATEGIES FOR CLIMATE CHANGE ADAPTATION

Alberta
ENVIRONMENT

THE ASSESSMENT OF SELECTED DECISION TOOLS FOR EVALUATION OF STRATEGIES FOR CLIMATE CHANGE ADAPTATION

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TABLE OF CONTENTS

FOREWORD III
SUMMARY iv

1.0 INTRODUCTION 1

2.0 TOOL #1 VANDACLIM 2
2.1 Tool Description 2
2.2 Tool Layout/Components 2
2.3 Available Documentation 4
2.4 Input Required 5
2.5 Output Produced 5
2.6 Output Format 6
2.7 Evaluation 6
2.8 Status of the Evaluation: 7

3.0 TOOL #2 ADM/SCREENING TOOL 8
3.1 Tool Description 8
3.2 Tool Layout/Components 8
3.3 Available Documentation 11
3.4 Input Required 11
3.5 Output Produced 11
3.6 Output Format 12
3.7 Evaluation 12
3.8 Status of the Evaluation 13

4.0 TOOL #3 CROPWAT 14
4.1 Tool Description 14
4.2 Tool Layout/Components 14
4.3 Available Documentation 15
4.4 Input Required 15
4.5 Output Produced 16
4.6 Output Format 16
4.7 Evaluation 16
4.8 Status of the Evaluation 17

5.0 TOOL #4 WEAP 18
5.1 Tool Description 18
5.2 Tool Layout/Components 19
5.3 Available Documentation 19
5.4 Input Required 20
5.5 Output Produced 21
5.6 Output Format 22
5.7 Status of the Tool Evaluation 22

6.0 TOOL #5 ALFALFA 1.4 23
6.1 Tool Description 23
6.2 Tool Layout/Components 23
6.3 Available Documentation 24
6.4 Input Required 24
6.5 Output Produced 25
6.6 Output Format 25
6.7 Evaluation 26
6.8 Status of the Evaluation 27

7.0 CONCLUSION 28

FOREWORD

Adaptation is a necessary and important response to climate change. It is a risk management issue that is not dependent on what causes the climate to change. Decisions about adaptation measures are very complex. Special computer programs (decision tools) are available to help process information for the selection, assessment and decision-making related to climate change adaptation.

The United Nations Framework Convention on Climate Change (UNFCCC) has compiled a "Compendium of Decision Tools to Evaluate Strategies for Adaptation to Climate Change". There are a large number of such tools. Some are general; others are region or sector specific. Many are available free while some can be modified for special applications for a fee. The input requirements vary considerably. The purpose of this project is to provide a first look at selected decision tools, their data requirements and potential for application in Alberta. Such information would be useful for adaptation strategy development and implementation.

Raymond Wong, Ph.D.
Project Coordinator

SUMMARY

This study examines five different decision tools for evaluating climate change adaptation strategies. The five tools examined were VandaClim, ADM/Screening Tool, CropWat, WEAP, and Alfalfa 1.4. All five tools were selected from the "Compendium of Decision Tools to Evaluate Strategies for Adaptation to Climate Change", prepared for the United Nation's Framework Convention on Climate Change Secretariat by Stratus Consulting Inc. The tools examined range from simple to complex. Each tool is directed at different sectors affected by climate change.

Each tool was evaluated using the following criteria:

- Whether it was easy to use,
- The usefulness of the output,
- Whether the decision tool functions properly when using Alberta data,
- Whether the tool is appropriate to use for Alberta.

Generally all tools examined had the potential to be applied to Alberta's situation. Some tools require small modifications before they can be used for Alberta.

VandaClim has good potential to be used for Alberta but requires a version to be designed specifically for Alberta. The ADM/Screening Tools are simple tools for a broad approach to comparing different adaptation strategies. These tools could easily be applied to Alberta's situation. CropWat is a more complex tool, which could be applied to Alberta's agriculture. WEAP is also a more complex tool and could be applied to Alberta's water resource sector. Alfalfa 1.4 a tool specifically designed to assess the effect of climate on alfalfa and could be applied to Alberta with some modification.

1.0 INTRODUCTION

An important response to climate change is adaptation. By predicting climate changes and assessing potential effects on different sectors, adaptation strategies can be developed. Adaptation strategies are needed to maximise any beneficial effects and minimise any negative impacts of climate change.

The purpose of this study is to examine five different decision tools for evaluating climate change adaptation strategies. This study also examines the applicability of these decision tools to Alberta. The tools are basically computer software programs for adaptation decision-making. Each tool applies to different sectors subject to the effects of climate change.

All of the decision tools were selected from the "Compendium of Decision Tools to Evaluate Strategies for Adaptation to Climate Change" prepared for the United Nation's Framework Convention on Climate Change Secretariat by Stratus Consulting Inc. The tools were chosen as potentially applicable tools if:

- they could be obtained at little or no cost,
- were relevant to Alberta,
- were capable of evaluating alternative climate change adaptation strategies,
- could operate at a provincial scale or smaller,
- have available documentation (user guides, manuals, etc),
- use accessible data.

Once it was determined if a decision tool had potential it was examined further. The decision tool's functions, components, required inputs, produced outputs, output format, and documentation were determined and summarised. Then the tool was evaluated using data relevant to Alberta. The decision tool was evaluated using the following criteria:

- Whether the tool is easy to use,
- The usefulness of the output,
- Whether the decision tool functions properly when using Alberta data,
- Whether the decision is appropriate to use for Alberta.

2.0 TOOL #1 VANDACLIM

2.1 Tool Description

What is it? It is a decision tool applicable to a country or a region for assessing climate change vulnerability and adaptation.

Who designed it? The CC:TRAIN/VANDACLIM decision tool was developed by the Centre for Environmental and Resource Studies (CEARS), University of Waikato from the Global Environment Facility and United Nations Development Programme, and is executed by the United Nations Institute for Training and Research in partnership with the Climate Change Secretariat and UNEP's Information Unit on Conventions.

How to obtain it? The program and software information is located online at the following address: http://www.geic.or.jp/cctrain.

Contact person? Richard Warrick, University of Waikato, Hamilton, New Zealand. E-mail: r.warrick@waikato.ac.nz.

What is the cost? The documentation and demonstration version of the software is available free of charge. If an Alberta-specific version of the software was desired, a cost would be involved with design and development. This cost is to be determined upon consultation with the developer.

What does it do? The tool is designed to conduct a Vulnerability and Adaptation Assessment. The training package consists of eight modules and a software package (VANDACLIM). There is a fictional country (Vanda) used as a tutorial example. A package containing information about "Vanda" is also included. Sectoral impact models within VandaClim focus on the effects of climate change on the agricultural, human health, coastal and water resource sectors using different climate change scenarios.

Computer Requirements: The software requires an IBM compatible personal computer with Windows 95 or higher. Software was easily downloaded, installed and runs on the Department's computer system.

2.2 Tool Layout/Components

There are two components, the Modules and the VandaClim system.

Modules

The eight modules are as follows:

- Module 1: Scoping the Assessment
- Module 2: Selecting Methods
- Module 3: Developing Datasets and Baselines
- Module 4: Testing Methods
- Module 5: Constructing Scenarios
- Module 6: Analysing Impacts
- Module 7: Evaluating and Selecting Adaptations
- Module 8: Synthesis

These modules guide the user through the steps required to conduct a vulnerability and adaptation assessment.

VandaClim System

Accompanying the eight modules, is the VandaClim system. It is a country-scale Integrated Assessment Model (IAM). It incorporates output from a global climate model with a regional scale climate model and several sectoral impact models. The global climate model is known as MAGICC or Model for the Assessment of Greenhouse-gas Induced Climate Change. It has provided output including global temperature change. The main components of VandaClim are:

- Monthly climate data 1961-1990
- Scenario generator (includes output from MAGICC)
- Sectoral models for agriculture, coastal zone, human health, and water resources.

The scenario generator uses output from the MAGICC model to generate climate change scenarios for Vanda. The user must choose an emissions scenario and the low, best guess, and high case (range of uncertainty), and the year of interest. Then the user must choose a climate change pattern.

The sectoral impact models are designed for four sectors, which are important to Vanda. These are agriculture, coastal zone, human health, and water resources.

Agriculture - there are two agricultural components, 1) a degree day model which describes the thermal limit for grain maize. This can be used to predict land suitability. 2) a water requirement satisfaction index for grain maize.

Coastal Zone - The Bruun Rule and the Inunduation Model, are models dealing with the rise of sea level and its impacts on the coastal sector.

Human Health - A biophysical index which estimates the incidence of malaria, a threshold index for cholera, and an integrated approach to estimating secondary effects on other sectors are all included to deal with the human health sector.

Water Resources - There are three simple models included: 1) an atmospheric water balance model for describing the water situation on large scale. 2) a water balance-river discharge model for estimating river discharge. 3) a discharge-flood area model for estimating extent of flooding during the wet season.

2.3 Available Documentation

Modules: The modules describe in detail the steps required to conduct a vulnerability and adaptation assessment. The documentation refers to other sources of useful background information. Examples are provided.

Software: A system description is provided with the software, it consists of three main sections: an overview section, a scenario generator section and a sectoral impact model section. The overview section describes the climate data used as input as well as an overview of the program's different components. The scenario generator section describes the scenario generator component of the program and explains how it functions. This section includes visual examples of output graphs and maps. The sectoral impact model section includes a description of each individual sectoral impact model. The concepts behind the models are defined. The documentation does not explain all the possible options on the program's toolbar. Fortunately, the options are self explanatory and relatively easy to work through. There is some confusion as the documentation sometimes uses different names or refers to the individual models using general terms/topics rather than the actual title used on the tool bar menu in the program and on the "pop-up" title that appears when the pointer is above the icon. The following explains what terms are referring to what model:

Documentation Reference	Icon "Pop-up" Title	Toolbar Menu Title
degree day model	degree days model	degree days
grain maize model	grain maize model	grain maize
inunduation model	coastal inunduation model	coastal inunduation
bruun rule model	coastal erosion mdel	coastal erosion
malaria incidence	malaria epidemic potential	malaria
water balance – river discharge model	riverine flooding model (obviously an error)	discharge
discharge - flood area model	riverine flooding model	riverine flooding
atmospheric water balance model	aridity index	water balance

2.4 Input Required

Modules: The set of modules do not have a clearly defined set of required inputs but in order to follow the modules the user must have a thorough understanding of the following: the strategies being considered, available methods of adaptation strategy evaluation, important sectors of the region, available data and resources for the region, and climate change effects. The quality of the results depends directly on the knowledge of the user.

VandaClim: The VandaClim software uses basic monthly climate data (1961-1990 average). The climate data consists of monthly minimum and maximum temperatures, monthly rainfall, and monthly solar radiation interpolated to a 0.03 ° latitude/longitude grid. The software also uses output from the MAGICC model to generate scenarios. It can be assumed that an Alberta version of this software would require the same climate information.

2.5 Output Produced

Modules: After the modules are completed, the user will have a complete vulnerability and adaptation assessment, with scope, methods, baselines, possible scenarios, sector-specific impacts, adaptation options, assessment of vulnerability and adaptation strategies.

VandaClim Software:

MAGICC: (MAGICC provides the database of potential scenarios on which the program is based on.) The user can view the different scenarios included in MAGICC in both graph or table form. The information displayed is the low, best guess, and high case values for projected temperature change over time.

Scenario Generator: The scenario generator produces contour maps of precipitation, minimum, maximum, and mean temperatures for individual months, seasonal averages, an annual averages. These maps are based on the user choosing an emissions scenario (generated by MAGICC, low, best guess, or high case and a year of interest (5 year increments from 1990 - 2100).

Impact Models: There are several impact models included in VandaClim producing different results. Several of the impact models are not applicable to Alberta's sectors. There are eight sectoral impact models:

1) Degree Days - produces a contour map of degree days based on the thermal limit of grain maize.
2) Grain Maize - produces a contour map of growth of grain maize based on water requirement satisfaction index and climate threshold limits, but software always errors before producing map.

3) Coastal Inundation - produces a contour map of coastal inundation (loss of surface land - as sea level rises, low lying areas become submerged).
4) Coastal Erosion - produces graphs of sea level rise, total sea level rise, equilibrium shoreline change, shoreline change, change in shoreline over time, shoreline surge erosion.
5) Malaria - produces a contour map of the epidemic potential of malaria based on temperature and rainfall limitations.
6) Discharge - generates river discharge levels based on monthly precipitation and potential evapotranspiration but always errors before producing results.
7) Riverine Flooding - produces a map of flood extent based on calculated peak discharge but always errors before producing results.
8) Water Balance - calculates in a spatial context, the difference between potential evapotranspiration and rainfall (monthly or seasonal) but always errors before producing results.

2.6 Output Format

Modules: The modules do not produce results on their own but guide the user through the steps to producing a vulnerability and adaptation assessment. The level of detail, accuracy and output format depend on the user.

Scenario Generator: The scenario generator produces output (precipitation, maximum temperature, minimum temperature, and mean temperature) in the form of a contour map

MAGICC (Global warming database): The global warming database displays projected global temperature change over time for different climate change scenarios in the form of a graph and a table.

Sectoral Impact Models: The following models produce results in a contour map format: Degree Days, Grain Maize, Coastal Inunduation, Malaria, Riverine Flooding, Water Balance. The following models produce results in a table and graph format: Coastal Erosion and Discharge.

2.7 Evaluation

Is it easy to use? **Modules:** The modules are relatively easy to follow, as everything is broken down into steps. The modules contain a large amount of detail therefore requires a fair amount of time to work through. **VandaClim:** The software is also fairly easy to use, the toolbar and options are user-friendly and self-explanatory. The software produces nice visual results. The manual does not describe the software very well. The manual describes the theory behind the models but does not describe the steps of using the software in adequate detail.

Are the outputs useful? **Modules:** The modules could be useful as a guide to working through a vulnerability and adaptation assessment for Alberta. However, the quality of the assessment depends on the knowledge of the person performing the assessment. In order to perform a good quality, in-depth assessment, one requires knowledge of the study region, its important sectors, and climate change adaptation strategies. The modules function only as a guide, no actual results are produced by the tool itself. A complete assessment is created by the information entered by the user. The modules provide instruction and a framework to follow. **VandaClim:** As it is, VandaClim is of no use to Alberta because it is designed for a different region (imaginary country of Vanda). If a similar tool was designed specifically for Alberta, the tool could incorporate Alberta's geography and address Alberta's important sectors, such as agriculture and water resources. For example, it could be possible for the tool to spatially map crop performance for different climate change scenarios.

Can the tool function properly with Alberta data? **Modules:** The modules work properly with Alberta's situation. The modules could be used for any region. In order to use the modules, the user requires information regarding climate change scenarios, potential climate change adaptation actions, important sectors and socio-economic information about the region in question. **VandaClim:** Unfortunately, VandaClim will not work properly with Alberta's data. In order to function properly another version would have to be created based on Alberta's geography, climate, and important sectors. This would have an undetermined cost associated with it.

Is the decision tool appropriate to use for Alberta? **Modules:** The modules would be appropriate to use for Alberta. The modules could be applied to any scale or region. **VandaClim:** As it is, VandaClim is of no use to Alberta because it is designed for a different region (imaginary country of Vanda). A special version has to be designed for Alberta. Environment Canada has commissioned the development of a version for use in Canada.

2.8 Status of the Evaluation:

VandaClim can be applied to Alberta with appropriate modifications by the developer. VandaClim is set up based specifically on Vanda's (an imaginary country included with the software and modules) geography, climate information, and important sectors. This can be changed with an appropriate software licensing agreement. It may be possible to have an Alberta version of the software created at some cost. Examining Vandaclim and how it operates provides an idea of what an Alberta version of the software could offer.

3.0 Tool #2 ADM/SCREENING TOOL

3.1 Tool Description

What is it? The Screening Adaptation Options (referred to as Screening Tool) and the Adaptation Decision Matrix (referred to as ADM) are two separate matrix-based decision tools. They can be used together therefore they are evaluated together in this report. The Screening Tool can be used first as a preliminary step before using the ADM.

Who designed it? Stratus Consulting Inc., Boulder, Colorado, USA.

How to obtain it? Tool description and contact information is available online at http://www.stratusconsulting.com.

Contact person? Joel Smith, Stratus Consulting Inc., Boulder, Colorado, USA
e-mail: jsmith@stratusconsulting.com.

What is the cost? The documentation and spreadsheet are available free of charge.

What does it do? Together the two tools are used to rank potential adaptation strategies based on costs, whether it meets objectives, implementation barriers, etc. By using these tools the user will be able to compare the different strategies to each other based on the resulting scores. To use the tools together, the user needs to work through four main steps. The first step is Measures, then Screening, then Decision, and then Barriers.

Computer Requirements: An IBM-compatible 286; Lotus 1-2-3 or Excel spreadsheet software helpful. Software was used on the department's personal computer without any difficulties.

3.2 Tool Layout/Components

The following is a description of each step:

Step 1: Measures

The first thing the user has to do is to identify potential measures/strategies to be evaluated. These measures should act to anticipate climate change, not react to climate change. Adaptation measures should relieve the negative effects of climate change and take advantage of the positive effects. Due to the uncertainty of climate change, it is preferable to have measures that are beneficial even in the absence of climate change.

At this point, the user needs to identify vulnerable sectors, regions, systems and populations. The sensitivity and vulnerability of the region needs to be determined. This is when vulnerability assessments that have been performed on the regions/sectors are to be examined and reviewed. The user also needs to consider the value of the affected resources (economic impacts) and the reversibility of damage. High value resources and irreversible impacts should take priority. The documentation supplied with the tool includes an example of measure identification for the following sectors: fisheries, forestry, energy, water, agriculture, and coastal areas.

Step 2: Screening Tool

This tool consists of a matrix designed to narrow down a list of possible adaptation measures. The matrix sets up a series of criteria and the different potential measures are evaluated against the criteria.

Evaluation consists of yes/no answers only, there are no numeric values assigned. This gives a quick, qualitative evaluation. This should be combined with expert judgement otherwise measure evaluation could be subjective. This is a quick and easy way to eliminate unsuitable measures when you are considering an unmanageable number of potential measures. The issues examined by the screening tool are effectiveness, costs, benefits, feasibility, priority, targets of opportunity, and consistency. The adaptation measures with the most yes answers should be evaluated further. Usually the list is narrowed down to between two and five top measures. The documentation supplied with the tool includes examples of a screening tool matrix for the following sectors: fisheries, forestry, energy, water, agriculture, and coastal areas.

Explanation of Screening Criteria:

High Priority: Does the adaptation measure address irreversible/catastrophic effects, or unfavourable trends? Irreversible/catastrophic effects get high priority.

Target of Opportunity: The measure that addresses infrastructure decisions, action plans, research and development are preferred.

Effectiveness: Will the measure be effective? The measure needs to be flexible and complement long term development strategies. The measure must be beneficial to stakeholders.

Other Benefits: Is the measure justified under current climate conditions, not just for climate change?

Low Costs: Due to the uncertainty of climate change it is hard to endure high costs. Measures with low associated costs are preferred.

Low Barriers: What are potential barriers? Will the measure be accepted and supported? Barriers could possibly be legal, social, market, or technological.

Consistent: The measure also must be consistent with adaptation measures of other sectors.

Step 3: Decision:
Adaptation Decision Matrix (ADM)

The next step is the Adaptation Decision Matrix. This allows the user to apply a more quantitative evaluation of the remaining potential adaptation measures. The ADM is also a matrix-based tool, which calculates cost-effectiveness. It will determine the most efficient measure. The ADM ranks multiple measures based on how well policy objectives are met and the estimated costs. Costs are assigned a value in dollars while benefits are assigned a value based on a common metric, but not necessarily in monetary terms. The measures can be compared to each other, based on scores calculated. Scores are dependent on the measure's strengths and weaknesses.

First the user needs to identify the policy objectives of each measure being considered. Each policy objective is assigned a weight to indicate its relative importance. Then the user scores how well policy objectives are met on a 1 to 5 scale (one is the lowest score and five is the highest score). The user also needs to determine different scenarios that may be part of the evaluation. You can include several different scenarios on the decision matrix.

A total score is calculated. Total score is calculated by adding up the scores on how well objectives are met (each are multiplied by the weighting factor assigned to each policy objective). Cost effectiveness is also calculated by dividing cost by incremental benefit (total score for the measure minus the total score for the current policy - the difference between the two measures).

Once the matrix is completed the user is able to compare total score, cost, cost - effectiveness of multiple measures. This is important because two measures may have similar total scores but one may have significantly higher costs. All three values need to be considered when comparing measures against each other.

The documentation supplied with the tool includes examples of an adaptation matrix for the following sectors: fisheries, forestry, energy, water, agriculture, and coastal areas.

Step 4: Barriers

The ADM/Screening Tool examines the cost barriers (in monetary terms) associated with each measure but there may be other barriers that should be considered in-depth. The user needs to identify other barriers associated with each adaptation measure. Barriers may be cultural, technological, market related, or legal. A table is used to examine these barriers. The following aspects are considered:

Response - What action will be taken to overcome the barrier?
Time - How long will it take to overcome the barrier?
Costs - What costs (monetary) are associated with overcoming the barrier?
Difficulty - What is the overall difficulty level of overcoming the barrier?

A three-point system is used to rank the level of difficulty where X means easiest to overcome and XXX means most difficult to overcome. The documentation supplied with the tool includes examples of barrier evaluation for the following sectors: fisheries, forestry, energy, water, agriculture, and coastal areas.

3.3 Available Documentation

The documentation included with the software is very detailed. Each step is explained and includes examples. Each matrix is also explained in great detail. Detailed examples are provided for the following sectors: fisheries, forestry, energy, water, agriculture, and coastal areas.

3.4 Input Required

- The adaptation measures being considered.
- The strengths and weaknesses of each adaptation measures being considered (barriers, costs, benefits etc) (see Screening Criteria).
- The objectives of the adaptation measures being considered.
- The climate scenarios being examined.
- The costs (quantitative value) associated with each adaptation measure.
- Knowledge of how well objectives are met by adaptation measures.

3.5 Output Produced

When the Screening Tool (Step 2) is completed, a simple table is produced. The table identifies which strategies are superior to others in a non-qualitative manner. The adaptation options being considered are listed down one side and the screening criteria are listed across the top. The options are assigned yes/no answers depending on how they perform against the screening criteria. The options with more yes answers are superior.

The Adaptation Decision Matrix produces a matrix, which ranks the potential adaptation measures according to a total score calculated for each individual measure. The options are listed down the side and the objectives are listed across the top. Each objective is

assigned a weight. The options are assigned a score by the user on how well they meet the objectives and a total score is calculated by the matrix. Cost - Effectiveness is also calculated by the matrix.

3.6 Output Format

Step 1: The output format is dependent on how the user chooses to display their results.
Steps 2, 3, and 4: The output format is a spreadsheet matrix.

3.7 Evaluation

Is it easy to use? The tools are both very simple and easy to use, although you need to thoroughly understand the measures being evaluated. The tools' documentation is very complete and easy to understand. Detailed examples of each step for six different sectors are included with the tools. A complete example (from start to finish) is also supplied with the tools.

Are the outputs useful? **Screening Tool:** The screening tool would be useful for quickly identifying the superior adaptation measures when considering a large number of potential measures. Strengths and weaknesses are quickly identified.

Adaptation Decision Matrix: The ADM is a useful tool for examining the top few adaptation measures being considered. It examines the strengths and benefits of each measure in a more in-depth and quantitative manner. It is useful because it considers both how well objectives are met and cost-effectiveness. Two measures may meet objectives equally well but one may not be very cost-effective. The ADM is also useful because it allows the user to compare benefits that cannot be expressed in monetary terms. Often the benefits of climate change adaptation are not expressed in monetary terms.

Can the tool function properly with Alberta's data? These tools function properly with Alberta's data. Data required includes strengths and weaknesses of adaptation measures, objectives of adaptation measures, effectiveness of adaptation measures, etc. This tool is flexible enough that it could be used for any region or sector.

Is the decision tool appropriate to use for Alberta? These two tools would be appropriate to use for Alberta or any other region.

3.8 Status of the Evaluation

Overall, the Screening Tool and ADM are effective tools. The tools complement each other and work well together. A drawback to these tools is the need for expert judgement, which may invoke costs. The evaluation of the different strategies is dependent on scores assigned by the user. This allows for subjectivity. This tool would be better off being used by a team of users (preferably a team of expert in different areas) than an individual user. This would allow for various expertise and knowledge to contribute to scoring.

4.0 Tool #3 CROPWAT

4.1 Tool Description

What is it? CropWat for Windows Version 4.2.

Who designed it? It is a decision support tool developed by:
Derek Clarke (Institute of Irrigation and Development Studies, Southampton University, Southampton, UK), Martin Smith (Food and Agriculture Organization of the United Nations, Rome, Italy), and Khaled El-Askari (National Water Research Center, Cairo, Egypt).

How to obtain it? The tool's documentation and software can be found on the Food and Agriculture Organization of the United Nations (FAO) website at: http://www.fao.org/ag/agl/aglw/cropwat.htm. The documentation and software is available free of charge. There are several slightly different versions. I chose the Cropwat for Windows version because it is designed to work in the Windows environment and has been improved over earlier versions.

Contact person? Use the above website for contact and technical support.

What does it cost? The software and associated documentation is available free of charge.

What does it do? CropWat calculates reference crop evapotranspiration. The resulting values are then used in crop water requirement and irrigation scheduling calculations (using the Penman - Monteith methodology). The tool is used to develop irrigation schedules under different management conditions and to develop different water supply schemes. This tool evaluates rainfed production, drought effects and the efficiency of irrigation practices.

Computer Requirements: The program requires a PC supporting DOS or Windows. There are three versions of CropWat. CropWat version 5.7 is written in BASIC and runs in the DOS environment. CropWat version 7.0 in Pascal, which is a DOS-application, but still runs in all MS - Windows environments. CropWat for Windows is written in Visual Basic and runs in the Windows environment. The version chosen for this evaluation was the CropWat for Windows. The program was installed on the department's personal computer with no difficulties.

4.2 Tool Layout/Components

CropWat for Windows works like any other Windows applications with a toolbar with pull-down menus. Most of the options are self-explanatory. The documentation accompanying the software also explains each option in detail. The following menus are found along the toolbar:

File	Retrieve, Save, Configuration, Text Editor, Windows Calculator, Exit
InputData	Climate, Evapotranspiration, Rainfall, Crops, Soil, Data Status
Schedule	Criteria, Scenario, Recalculate, Irrigations, User Adjustments
Tables	Climate & Evapotranspiration, Rainfall, Crop Water Requirement, Irrigation Schedule
Graphs	Climate & Evapotranspiration, Rainfall, Cropping Pattern, Crop Water Requirement, Irrigation Schedule
SaveReport	Climate & Evapotranspiration, Rainfall & Evapotranspiration, Crop, Cropping Pattern, Soil, Crop Water Requirement, Irrigation Schedule
Options	Calculation Methods, Default File Locations, Sound, Defaults, Save
Window	Cascade, Tile Vertical, Tile Horizontal, Tool bar, Status Bar
Help	Contents, Search for Help on About

4.3 Available Documentation

The manual included with the software is a detailed user guide. The guide includes instructions for installing the program, step by step instructions for using the program, and examples of possible outputs. All the program layout/component details are identified in the manual. Common problems in using the software are also identified. The manual refers to online help information and contact people for technical support. Background concepts and assumptions are identified and explained. This documentation is very comprehensive and easy to use.

4.4 Input Required

The following is a list of the input required to run the program.

1. Monthly climatic data: temperature, humidity, windspeed, and sunshine. A reference crop evapotranspiration will be automatically calculated (or entered by the user).

2. A cropping coefficient: Crop coefficient files are included with the program for many different crop species.

3. Monthly rainfall data.

4. Cropping Pattern(s): User must enter cropping patterns (crop file names and planting dates.)

5. Schedule Criteria: User must specify desired scheduling criteria.

6. Soil type: Soil type files are included with the program.

4.5 Output Produced

This program will produce graphs and tables of both input data and results. This is an advantage as it provides the user with a visual interpretation of both input values as well as calculated results.

The following tables are produced:

- Climate Data: (input)
- Reference Crop Evapotranspiration: (calculated estimates)
- Rainfall: (input and calculated effective rain)
- Crop Water Requirements: (calculated)
- Daily Soil Moisture Balance and associated yield reduction
- Irrigation Schedule & Soil Moisture: (calculated)

The following graphs are produced:

- Climate Data: (input) includes temperature, wind, humidity, sunshine, and rainfall
- Reference Crop Evapotranspiration: (calculated estimates)
- Cropping patterns: (input) includes planting dates/areas
- Crop Water Requirements: (calculated) including seasonal variation, Irrigation Water Requirement, and Evapotranspiration

4.6 Output Format

The results are presented in either table format or graph format (see above list).

4.7 Evaluation

Is it easy to use? The CropWat decision tool is very easy to use. The software is simple with self - explanatory pull-down menus. The manual describes how to use the tool step by step. The manual clearly describes the tool functions and abilities.

Are the outputs useful? Output from this tool can be used to predict crop water requirements and explore irrigation scheduling options based on different climate and crop situations.

Can the tool function properly with Alberta data? The tool functions with Alberta's climate data. The program requires basic climate data, which is readily available for the province.

Is the decision tool appropriate to use for Alberta? This would be of interest to Alberta due to the importance of the agricultural sector. Climate change may bring changes to agricultural water demand and available water supply. This tool may help examine potential adaptation measures under different situations.

4.8 Status of the Evaluation

The CropWat program has an advanced section which describes more complex options such as scheduling scenarios, user defined irrigations, user adjustments, and exporting files to spreadsheets. This allows the user to enter non-standard values for irrigation scheduling, soil moisture balance, as well as save and export files.

5.0 Tool #4 WEAP

5.1 Tool Description

What is it? WEAP stands for Water Evaluation and Planning System. WEAP is a PC-based water planning tool for water resource assessment and developing sustainable resource plans.

Who designed it? Stockholm Environment Institute - Boston, Tellus Institute.

How to obtain it? The software and associated documentation is online at http://www.tellus.org/seib/indext.html.

Contact person? Use the above website for contact and technical support.

What does it cost? The documentation and the review version of the software is available free of charge. Licensing for a full functioning version is available for $750.00 (US).

What does it do? The WEAP program provides a framework to analyse a supply and demand relationship of water systems. This tool can be used for rivers, creeks, canals, reservoirs, and groundwater resources. The tool can examine different sets of conditions.

The WEAP program has three possible functions/abilities:

1) **Database ability:** the ability to maintain water supply and demand information.
2) **Forecasting ability:** the ability to simulate demand, supply, flows, storage, and pollution generation, treatment and discharge.
3) **Policy Analysis ability:** the ability to evaluate water development and management options.

Computer Requirements: WEAP runs on an IBM-compatible personal computer with DOS version 3.1 or higher. WEAP requires at least 10 MB free hard drive and at least 640 MB of RAM with at least 580 KB free for WEAP use. A colour VGA monitor and mouse are required. In order to print tables/graphs the DOS program GRAPHICS.COM is required. The Department's computer does not have this program at the present moment.

5.2 Tool Layout/Components

Main Screen: The main screen displays a map of the components of the water system. Components consist of demand sites, the main river pathway, tributaries, links, etc. It is here that your components can be added, deleted, and moved around. The user can also edit specific components by right clicking on them individually.

Pull-Down Menus: Along the top of the main screen are a series of pull-down menu options. They are as follows:

File: there are several options dealing with editing your area/scenario (creating, renaming, etc.).

View: user can define what is displayed or hidden in your area.

General: user has the option of choosing your units and years, hydrological pattern, and pollutants.

Demand: user supplies monthly demand data, variation, loss and reuse, drivers, elasticity's, pollution generation, and end-use costs.

Network: user can edit data regarding transmission links (capacities and losses), wastewater treatment plants (wastewater routing and treated effluent routing), and costs.

Supply: user can edit local supply data (groundwater, reservoirs) and specific river data for several different rivers.

Reports: the user can access and format all the reports produced by WEAP.

Help: user can find help regarding the program, system information, network configuration, printer code, and to register.

5.3 Available Documentation

A detailed user guide is included with the program. The guide can be downloaded free of charge from the program's web site. The user guide provides a detailed explanation of the program's abilities and functions. Step by step instructions of how to set up your own scenario are given. Required input, editing options, and supply and demand functions are all defined. The guide provides visual examples to support the explanations. The installation instructions are included, as well as operating tips, instructions for importing data, and a sample data set. The calculation algorithms are also included in the user guide.

5.4 Input Required

(Setting Up)

- Boundaries (political or geographical)
- Base year and end year (defines time horizon being considered)
- Monthly inflow or annual inflow for surface water hydrology

(Demand)

- Present and future socio-economic development measures:
  - Population
  - Industrial output
  - Agricultural output
  - Urban and rural domestic development
- Water requirements (per capita, per production output, per activity)
- Basic water use data for each sector/specific water users
- Existing water use studies for the study area and data from national, provincial and municipal agencies
- Population projections for cities and towns
- Production activity level projections for industry and agriculture
- Pollution discharges, locations and quantities
- Cost data for a particular end uses

(Network)

- Water consumption: demand sites, evaporation, embodied in products, other losses
- Transmission link capacities and losses
- Wastewater and effluent routing
- Wastewater treatment plant ratings for capacity and pollutant removal
- Costs for general infrastructure, wastewater treatment plants, pumps etc.

(Supply)

- Streamflow gauge records and their locations
- Estimates of streamflow for ungauged locations
- Reservoir storage levels, volume - surface area - elevation relationships, net monthly evaporation, operating rules for fish and wildlife, recreation, hydropower, water supply, and other conservation uses
- Groundwater recharge rates, gains from and losses to river
- Flow requirements at river reaches for: recreation, water quality, fish and wildlife, navigation, other conservation purposes, and any downstream obligations

5.5 Output Produced

WEAP can produce monthly analysis of demand site requirements and coverage, streamflow, instream flow requirement satisfaction, reservoir and groundwater storage, hydropower generation, evaporation, transmission losses, wastewater treatment, pollution loads, and costs.

Reports are produced by WEAP in the following areas: Demand, Resources, Pollution, Costs, and Data Echo. The following is a list of reports produced by WEAP:

Demand

- Final Demand and Supply Requirements
- Supply Delivered
- Coverage
- Unmet Supply Requirement
- Demand Site Inflows and Outflows

Resources

- Area Inflows and Outflows

(Rivers)

- Streamflow
- Node and Reach Inflows and Outflows
- Minimum Flow Requirements
- Net Evaporation (including reservoirs)
- Groundwater Flows into River Reaches

(Groundwater)

- Inflows, Outflows and Storage
- Storage Summary

(Reservoir)

- Inflows, Outflows, and Storage
- Storage summary
- Hydropower generation
- Transmission Link Losses
- Conjunctive Use Link Losses
- Other Local Supplies

Pollution

- Pollution generation
- Pollutant loads
- Wastewater treatment

Costs

- End-use
- Demand Site
- Transmission Link
- Conjunctive Use Link
- Wastewater Treatment Plant
- Wastewater Routing
- Treated Effluent Routing
- Supply
- Total

Data Echo

- Configuration
- Demand
- Network
- Supply

5.6 Output Format

WEAP can compare up to nine different scenarios side by side. WEAP produces a large quantity of reports. All reports have many different formatting options. Analysis can be presented as monthly or yearly. Reports can be formatted as graphs or tables. Graphs can be produced in many different chart formats. Possible chart formats for most reports include: clustered bar graph, stacked bar graph, line graph, or exceedance graph. The user also has the options of changing units, year, colour, background, and gridlines.

5.7 Status of the Tool Evaluation

The inputs and outputs of the program have been identified and summarised. The amount of data inputs required is quite large therefore Alberta's data will not be gathered for testing at this time.

Currently a new version of the program is being worked on. The new version will run on Windows 95/98/2000/NT and will have new features including GIS display capability, more sophisticated modelling ability, and linkage to Excel. Licensed users are allowed free access to all new or upgraded versions as they become available.

6.0 Tool #5 ALFALFA 1.4

6.1 Tool Description

What is it? Alfalfa 1.4 is a program which simulates the growth and development of the alfalfa plant.

Who designed it? R. Ford Denison and Bob Loomis of the Division of Agriculture and Natural Resources, University of California, Davis, California,.

How to obtain it? The software and information can be found online at the following address: http://axp.ipm.ucdavis.edu/IPMPROJECT/alfalfa.html.

Contact person? R. Ford Denison, Agronomy and Range Science, University of California, Davis, California.

What is the cost? The software can be downloaded free of charge on the website (see above). The documentation can be ordered for 7 dollars (US). The software on disk can be ordered with the documentation for 25 dollars (US). Ordering instructions are given on the website listed above.

What does it do? The tool can simulate the growth of up to five age classes of stems and can also simulate the growth of underground structures over ten soil layers. The tool can study the effects of temperature, radiation, water deficit, and carbon supply on the growth and development of the alfalfa plant. This tool can be applied to testing different adaptation strategies.

Computer Requirements: This program runs in DOS, Windows, or Macintosh environments.

6.2 Tool Layout/Components

First a main screen comes up in DOS. Here the user has the option of choosing input files and other options. Once the user has done this, the user must type "B" and press "enter" to begin the simulation run.

Once the run is complete the user can observe a split graph displaying the results. The user then has the following options: Plot, List, Resume, File, or Exit. "Plot" allows the user to plot specific variables. "List" allows the user to list the results of specific variables in table form. "Resume" results in the continuation of the simulation. "File" can be used to save the results to another file. These results can be used as an initial condition file for another simulation. "Exit" allows the user to exit the program.

6.3 Available Documentation

A detailed program manual is included with this tool. The manual describes the theory and equations on which the model is based. The manual describes how the growth processes are simulated by the model. Step by step instructions for running the program are also included. Visual examples are provided to support these instructions. Input requirements are clearly listed. The documentation also includes a listing of all global variables and program files in Alfalfa 1.4.

Experience and knowledge in agronomy and computer programming would be helpful in understanding the tool and the documentation.

6.4 Input Required

The following summarises input variables used by Alfalfa 1.4:

- Cultivar-specific parameters and functions
- Location specific parameters and functions
- Initial values of all state variables/conditions
- Daily average weather data (minimum of 90 days):
  - month
  - day
  - rainfall (in)
  - maximum air temperature (F)
  - minimum air temperature (F)
  - windspeed (mph)
  - wet bulb temperature (F)
  - dry bulb temperature (F)
  - maximum soil temperature (F)
  - minimum soil temperature (F)
  - pan evaporation (in)
  - total solar radiation (Ly/day)
- Experiment specific treatments
- Default settings for file choices and screen graphics
- Expected maximum values for auxiliary variables

6.5 Output Produced

The following summarises the outputs produced by Alfalfa 1.4:

- Total yield
- Air temperature (hourly)
- Photosynthetically active radiation (PAR) below crop
- Fraction non-structural carbohydrate (NC) for root
- Fraction water content, soil layer 2 from top
- Leaf area index
- Hourly PAR reaching canopy layer 25
- Effect of NC on growth of shoot class 1
- Effect of NC on current photosynthesis
- Plant population
- Current soil temperature
- Effect of temperature on growth
- Effect of temperature on photosynthesis
- Daily PAR above canopy
- Daily photosynthesis
- Total daily respiration
- Daily transpiration
- Effect of plant water content on current growth
- Effect of plant water content on photosynthesis
- Losses due to shading and frost

6.6 Output Format

Alfalfa 1.4 uses run-time graphics to display the results in a two-part graph. The left portion of the graph display the results for the past 90 days while the right portion of the graph display the results of the past 24 hours. The results can also be displayed in text and table format. This format is automatically displayed when the user chooses the option B = Begin Simulation.

Using the PLOT option, variables can be plotted individually on a simple graph. The user simply chooses a variable(s)and a time interval. For example, air temperature can be plotted every four hours. Several variables can be displayed on the same graph. The same information can also be displayed in a simple table, listing the values and time intervals. The user simply uses the LIST option to do this.

6.7 Evaluation

Is it easy to use? A working knowledge of agronomy and computer programming is required to use this tool to its full extent. The actual functions of the tool are relatively simple to perform. However, the interpretation of results does require extensive knowledge of the physiology of the alfalfa plant and the general field of agronomy.

Modification of input files requires general knowledge of working with DOS and knowledge of the specific climate scenario being examined (site conditions, crop treatments, cultivar type, climate values, and initial conditions).

A background in agronomy and computer programming is required to understand the documentation. The documentation uses agronomic terms. Without the required background the theory and processes behind the model are quite difficult to understand. The documentation also provides the computer information (subroutines, executable code, etc.) and some computer programming knowledge is required to follow this.

Are the outputs useful? Output from this tool would be useful in evaluating different management strategies under different climate scenarios. The user can study the effects of changing planting dates, cultivar types, irrigation treatments, etc. The user can also modify climate inputs and study the impacts of different climate scenarios on the development of the alfalfa plant.

Can the tool function properly with Alberta's data? The tool functions properly using Alberta's weather data. However, to determine if the output is still accurate you need knowledge in agronomy. This tool was designed with California's climate and crop information in mind, its' accuracy when applied to Alberta's situation needs to be assessed.

It was not possible at this time to modify all inputs. Some inputs for this tool require knowledge of the specific situation being considered (location, crop type, crop treatments, climate conditions, etc.) The following summarises the other inputs that the user can modify to represent the situation being assessed.

Cultivar Specific File: This file allows the user to enter cultivar specific parameters and functions. For example, the physiological age for leaf senescence. The creation of a cultivar file requires extensive knowledge of cultivar parameters and response functions and requires a fair amount of time and research. The documentation mentions that it is possible to create a library of different cultivar files and the developer would be willing to assist in the development of these files.

Location Specific File: This file allows the user to enter information specific to the field conditions of the site being simulated. For example: wilting point of soil, latitude, bulk density of soil, etc.). This requires knowledge of the site in question.

Initial Conditions File: This file allows the user to enter the initial values of all the state variables. For example, plant population, stem number, etc. This requires knowledge of initial conditions or assumed initial conditions.

Weather File: This file allows the user to enter daily weather data. This requires knowledge of climate scenario being considered.

Experiment File: This file allows the user to enter experiment specific details. For example: irrigation treatments. Knowledge about experiment specific treatments required.

Default Settings: This allows the user to enter default settings for file choices and screen graphics.

Auxiliary Variables: This allows the user to enter expected maximum values for auxiliary variables.

Is the tool appropriate to use for Alberta? This tool would be of interest to Alberta due to the importance of the agricultural sector. Alfalfa is an important crop. However, further research is needed to determine if this tool accurately represents alfalfa development and physiology under Alberta's climate conditions. Since this tool was not designed for Alberta's climate or type of alfalfa there is a need to consider the possibility of a decrease in accuracy. Some modifications within the program may be required to accurately represent Alberta's climate and crop types.

6.8 Status of the Evaluation

In order to completely evaluate this tool with respect to Alberta's situation, additional region specific information for input files are required.

7.0 CONCLUSION

Generally all tools examined had the potential to be useful to some extent in evaluating climate adaptation strategies in Alberta. The tools are very different with some having a very broad focus and others having a very specific focus. All tools require some background knowledge in their areas of focus.

VandaClim consists of a training package and a software program designed to assist the user in conducting a vulnerability and adaptation assessment. VandaClim has good potential to be applied to an Alberta situation but would involve some cost. This is due to the need to have a version designed specifically for Alberta. ADM/Screening Tool are two simple spreadsheets designed to assist the user in comparing different adaptation strategies. ADM/Screening Tool could be used for Alberta. These tools use a very broad approach to evaluating climate adaptation strategies. CropWat is a Windows based application designed to evaluate different crop management strategies for various different crops. CropWat is a tool that could be applied to Alberta's agricultural sector and its relationship to climate change adaptation strategies. WEAP is a complex program designed to develop sustainable water resources management plans. WEAP is a tool that could be applied to Alberta's water sector but has extensive data requirements. Alfalfa 1.4 is a program designed to simulate the growth and development of the alfalfa plant. Alfalfa 1.4 has the potential to be applied to Alberta's situation but has a very specific focus. It is designed specifically for assessing the effect of climate on alfalfa.

Some difficulties arose when trying to apply these tools directly to evaluating climate adaptation strategies in Alberta. This was due to the fact that these tools were designed for areas other than Alberta. This means further research may be needed to adapt some of the tools for Alberta application.